Macroinvertebrate diversity and its ecological implications in two created wetland ecosystems

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Introduction

Wetland ecosystems are diverse ecosystems with fluctuating water levels, periods of oxygen stress, hydric soils with varied hydrological conditions. They are an important functional part of the landscape (Mitsch and Gosselink, 2000). Among the inhabitants of the wetlands, the macroinvertebrates are in close contact with water and are affected by changing water quality, periods of anoxia, accumulating organic matter (Craft, 2000). Some reasons for using macroinvertebrates for species diversity are their ubiquitous distribution, lifecycles of measurable duration which allows both long term and short term analyses (Rosenberg and Resh, 1993). Their sedentary nature also makes them good monitors of environmental changes as they constantly encounter the changes in the aquatic media that they inhabit (Rosenberg and Resh, 1993). Moreover, benthic invertebrate fauna are easy and inexpensive to sample, easy to identify with already established monitoring and diversity indices. However, large sample sizes are required for the correct biomonitering of any aquatic system when benthic invertebrates are used. (Hellawell, 1986).

Assessment of the diversity, distribution, richness and abundance of the macroinvertebrate (water column inhabitants and benthic) community often gives important clues of the functional status or health of the wetland (Hart et al., 1996). Biomonitering indices like the Benthic Index of Biotic Integrity, and the Biotic Condition Index are increasingly being used to assess the health of an aquatic body (Yoder and Davis, 1996). For example, a dominating number of corixids and chironomids in a aquatic ecosystem often indicates high pollution load, anoxic conditions and overenriched conditions because corixids like water boatmen are known to be pollution tolerant species and can tolerate highly anoxic conditions. They tend to replace the pollution sensitive species (Peckarsky, 1984). A similar study by Batzer and Resh (1992) in a seasonal wetland in California showed that a 50% manipulation of the vegetation cover lead to a significant increase in the number of pollution tolerant species like water boatman.

Thus, the main objectives of this present study are:

i. assessing the macroinvertebrate diversity in the two created wetlands;

ii. comparing them with previous year's data;

iii. characterizing the trophic structure and functional relationships between the different macroinvertebrate communities; and

iv. assessing the functional status/health of the 2 experimental wetlands based on this information.

Methods

Study Area

The study was conducted in 2 experimental basins in a created wetland – Olentangy River Wetland Research Park at The Ohio State University, a 30-acre research facility at Columbus, Ohio, Oct. 10-29, 2000 (Fig. 1). Both the basins are 1 ha each. One of the experimental wetland basins was originally planted and the other basin was unplanted. After a period of 7 years, both the basins are under vegetated cover. The unplanted basin has a dominance of cattail or *Typha*. These are perched wetlands with water being pumped in continuously from the Olentangy River (Frazier and Mitsch, 1999).

Sampling Locations

Samples were collected from Wetland 1 and Wetland 2 at three locations in the interior of each of the experimental basins (Fig.1b). The inflow, ouflow and middle regions were chosen for two main reasons. Inflow regions tend to be often more diverse in species richness than the outflow/middle regions due to their direct connection with the water source and active entry of floating fauna from the river source. Secondly, the sampling zones were kept constant for a more meaningful comparision of data from previous years.

Sampling Design

Three kinds of sampling devices were used for this study – Hester Dendy plates, bottle traps and dip nets.

Hester Dendy Plates

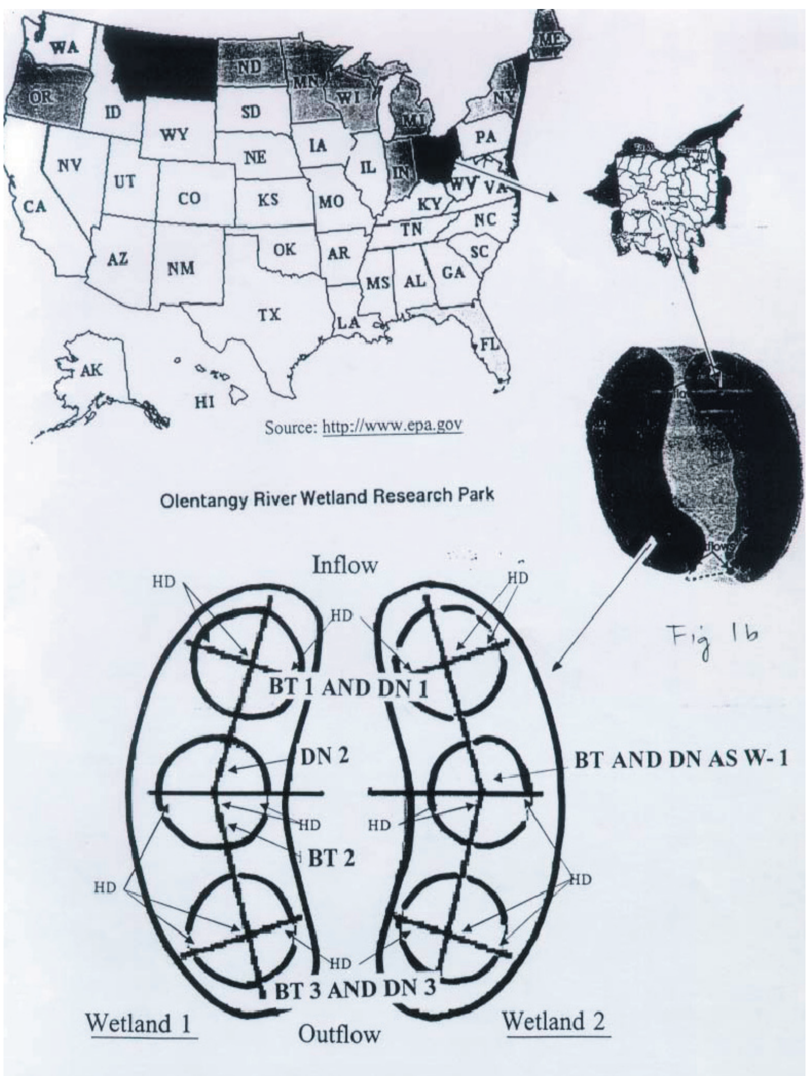
Eighteen Hester Dendy colonization plates were placed in the two wetlands (9 on each wetland) at the locations shown in Fig. 1. These were made up of 8cm x 8cm plates. They were tied from the boardwalk on Oct 10, 2000 and left undisturbed in submerged condition for 18 days and removed on Oct. 29, 2000. These plates were carefully removed from water without shaking the plates to avoid the dislocation of macrofauna attached to these plates. These plates were then gently washed with 70% ethyl alcohol and the organisms were then scraped onto a tray. These organisms were stored in vials containing 70% ethyl alcohol for further identification.

Bottle Traps

These were made from 2 liter plastic beverage containers with a slit on the bottom about 15 cms from the upper end. This formed the funnel to collect the macroinvertebrates when inverted under water (Custer and Johnson, 1998). These bottle traps were placed under water at the sampling locations shown in Figure 1. Stones and gravel were placed in the bottle traps to increase its weight for easy submergence under water. They were kept undisturbed for two days. The sampling process was repeated four times. The bottle traps were prepared for easy capture of actively swimming macroinvertebrate fauna. The slit in the bottles was opened using a knife and the contents of the bottle trap were placed in a tray. The macroinvertebrates were carefully sorted and placed in vials containing 70% ethyl alcohol.

Dip Nets

Dip nets with mesh size 800 x 900 um were used for qualitative sampling of macroinvertebrates in the wetlands. The dip nets were gently placed under water on Oct. 19, 2000 by walking on the boardwalks for two meters and then sweeping the net across the water surface by walking back across the boardwalk. This was done in order to prevent entangling of floating algal masses with the net. This sampling process was repeated 4 times in an interval of 2-3 days. The macro invertebrate collection was then sorted using forceps and then transferred into vials containing 70% ethyl alcohol.



Figures. 1a and 1b. Geographic Location of Olentangy River Wetland Research Park (ORWRP) with sampling sites in the 2 experimental wetland basins.

Identification

The invertebrates were then transferred to fresh vials containing fresh 70% ethyl alcohol for storage and subsequent identification. Organisms were identified to family and in some cases to genus level using Lehmkuhl, (1979), Gullan and Cranston (1994), Janus (1982), Pratt (1948), Pennak (1953), and Merrit and Cummins (1996).

Analysis

Calculation of Shannon Indices

Shannon Index (H) can be calculated as H=- (pi) (In pi). It is a measure of the species richness. H is the diversity index and pi is the proportion of individuals belonging to the ith species (Frazier and Mitsch, 1999). Higher values indicate that the population is more diverse and the chances of encountering members of the same species as the immediate next individual is lower. Using L' Hospital's rule, H can be shown to be identical with the entropy of order of 1 of the set (pi) in the mathematical information theory (Pielou, 1975).

Calculation of Species Evenness

The Shannon Index of Species Evenness (J) can be calculated as J=- (pi) (In pi)/ In s. The normal ranges for J are from 0-1. It indicates how evenly each species is distributed in a particular habitat. The total number of species are indicated by s.

Results and Discussion

A total of 572 macroinvertebrates representing 7 classes, 10 orders and 13 families were collected for this present study using all the 3 sampling methods (Table 1 a, b, c). 307 of these samples were from wetland 1 and 265 of them were from Wetland 2. The samples collected by Hester Dendy plates and bottle traps were for quantitative analysis and the samples collected by Dipnet were only for qualitative assessment of the macro invertebrate taxa (Table 2a). Table 2b compares and summarises the macroinvertebrate diversity from 1994-2000 (After Frazier and Mitsch, 1999).

Due to small sample sizes, a Chi square test was conducted in order to compare the samples from the two wetlands. The chi square value obtained was 79.712 with a degree of freedom or df value of 9. The probability value was less than 0.0001. This indicates that the number of macro invertrebrates in the two wetlands show a significant statistical difference. The difference could be due to the wide differences in the sample sizes. Wetland 1 showed a diversity of 43 specimen from Turbellarians, 6 Hirudineans and 39 Pulmonates (Family Planorbidae). Wetland 2 on the other hand showed a diversity of 2 Turbellarians, 26 Hirudineans and 9 Pulmontes. By excluding these taxa from our sample set, the chi square value changes to 10.099 with a df of 5 and a p=0.072. This indicates that the other taxa are comparable in abundance between the two wetlands.

A comparison of the Shannon indices for richness and evenness from 1997 to 2000 has been tabulated in Table 3. It indicates that the Shannon Index for richness using Hester Dendy plates has increased from 0.70 in 1999 (Frazier and Mitsch, 1999) to 1.56 according to our current study for Wetland 1. This is comparable to the diversity index calculated in 1997 for Wetland 1 by Speiles in 1997 which was 1.49. However, the Shannon Index for Wetland 2 is intermediate between H values from 1998 and 1999. The H values obtained by the bottle trap method was relatively high. The Species Evenness index (J) also increased from 0.36 in 1999 (Frazier and Mitsch, 1999) in Wetland 1 but decreased from 0.76 to 0.35. The J values using the bottle trap sampling method was similar for both the wetlands and is comparable to the mean J value calculated by funnel trap sampling by Frazier and Mitsch in 1999.

The bottle trap method was very effective in sampling a high diversity of macro invertebrate fauna in both Wetlands 1 and 2. The Hester Dendy plates were effective in sampling macro invertebrates in Wetland 1. The H value was lower than 1 using Hester Dendy plates in Wetland 2. A macro invertebrate study by Custer and Johnson at ORW in 1998 also showed that the Hester Dendy plates were not very effective in capturing a wide diversity.

A comparison of trophic distribution of the different macroinvertebrate fauna from the same sampling zones using bottle traps in the two created wetlands in Olentangy River Wetland Research Park has been shown in Figure 2 a-f. In all 3 sampling regions (inflow, middle and outflow) of Wetland 1 and 2, collectors had dominated the ecosystem in 1997 as shown by Spieles in 1997 and now is dominated by the scrapers according to the present study. The numbers of shredders and piercers had been low both in 1997 and 2000. The percentage of predators in the inflow site in Wetland I has shown an increase from 15% in 1997 to 23% in 2000. Similarly, there is a rise in predator percentage in the middle region of Wetland 2 from 5% to 20% and in the inflow region of Wetland 2 from 6-14 % from 1997-2000. This could be due to the increase in the number of Odonates like dragonflies and damselflies which are the primary macroinvertebrate predators in this kind of wetland ecosystem due to abundant and/or diverse food choices (Dabrowska, 1994). However, analysis of the total summed data from all three sampling sources in Wetland 1 and 2 shows the same trend of dominance by the collectors as shown by Spieles in 1997 (Fig. 3). The organic matter in the water could be one of the causative factors for the abundance of collectors as they filter feed on these particulate matter (Spieles, 1997).

The percentage distribution of macroinvertebrates collected using bottle traps in the inflow, middle and outflow areas of Wetland 1 and 2 has been shown in Figuew 4. Percent invertebrates sampled in the inflow region was 33% higher than samples collected by Custer et al. (1999) in Wetland 1 using Hester Dendy plates. The percentage of invertebrates sampled in the outflow region using bottle traps were 57% compared to 6% by the previous study in Spring, 1999 (Custer, et al., 1999). However, the percentage of invertebrates sampled in the middle flow region of both the

Table 1a. Macroinvertebrate diversity at the inflow sites in W 1 and W2 sampled with bottle traps.

SITE	CLASS	ORDER	FAMILY	GENUS	W1	W2
Inflow	Gastropoda	Basommatophora	Lymnaeidae	Lymnaea	4	1
	Gastropoda	Basommatophora	Physidae	Physa	45	8
	Gastropoda	Pulmonata	Planorbidae	Helisoma	8	6
	Hirudinea	Arhynchobdelia	Hirudinidae	Heamopis	0	22
	Crustacea	Anostraca			12	7
	Crustacea	Amphipoda			0	0
	Insecta	Coleoptera	Haliplidae	Peltodytes	0	0
	Insecta	Diptera	Chironomidae	Chironomus	0	0
	Insecta	Hemiptera	Corixidae		0	0
	Insecta	Odonata	Lestidae	Lestes	1	4
	Insecta	Odonata	libelulidae	Libellula	0	2
	Pelecypoda				0	0
	Oligochaeta				3	0
	Crustacea	Cladocera			0	0
	Unidentified				0	0
	Turbellaria	Tricladida	Planariidae	Dugesia	21	1

Table 1b. Macroinvertebrate diversity at the middle sampling sites in W 1 and W2 sampled with bottle traps.

SITE	CLASS	ORDER	FAMILY	GENUS	W1	W2
Middle	Gastropoda	Basommatophora	Lymnaeidae	Lymnaea	1	1
	Gastropoda	Basommatophora	Physidae	Physa	33	8
	Gastropoda	Pulmonata	Planorbidae	Helisoma	11	2
	Hirudinea	Arhynchobdelia	Hirudinidae	Heamopis	1	3
	Crustacea	Anostraca			0	1
	Crustacea	Amphipoda			0	0
	Insecta	Coleoptera	Haliplidae	Peltodytes	2	0
	Insecta	Diptera	Chironomidae	Chironomus	0	0
	Insecta	Hemiptera	Corixidae		0	0
	Insecta	Odonata	Lestidae	Lestes	0	3
	Insecta	Odonata	libelulidae	Libellula	0	1
	Pelecypoda				0	0
	Oligochaeta				4	0
	Crustacea	Cladocera			0	0
	Unidentified				0	0
	Turbellaria	Tricladida	Planariidae	Dugesia	1	1

Table 1c. Macroinvertebrae diversity at the outflow sites in W 1 and W2 sampled with bottle traps.

SITE	CLASS	ORDER	FAMILY	GENUS	W1	W2
Outflow	Gastropoda	Basommatophora	Lymnaeidae	Lymnaea	1	3
	Gastropoda	Basommatophora	Physidae	Physa	18	83
	Gastropoda	Pulmonata	Planorbidae	Helisoma	8	1
	Hirudinea	Arhynchobdelia	Hirudinidae	Heamopis	3	0
	Crustacea	Anostraca			0	2
	Crustacea	Amphipoda			0	0
	Insecta	Coleoptera	Haliplidae	Peltodytes	0	1
	Insecta	Diptera	Chironomidae	Chironomus	0	0
	Insecta	Hemiptera	Corixidae		0	0
	Insecta	Odonata	Lestidae	Lestes	0	1
	Insecta	Odonata	libelulidae	Libellula	0	1
	Pelecypoda				0	0
	Oligochaeta				0	0
	Crustacea	Cladocera			0	0
	Unidentified				0	0
	Turbellaria	Tricladida	Planariidae	Dugesia	1	0

Table 2a. Macroinvertebrate abundance and taxonomic richness in W1 and W2 in October 2000 at the Olentangy River Wetland Research Park.(HD=Hester Dendy plates; BT=bottle traps; DN=dip nets)

	ORW 1			ORW 2		
	HD	BT	DN	HD	BT	DN
Class Pelecypoda		0	0	X	0	0
Class Gastropoda						
Order Basommatophora						
Family Physidae	35	96	X	29	99	X
Family Lymnaeidae	10	6	X	2	5	X
Family Planorbidae	12	27	X	0	9	X
Class Hirudinea						
Order Arhynchobdellia						
Family Hirudinidae	2	4		1	25	
Class Crustacea						
Order Anostraca	1	12	X	5	10	X
Order Amphipoda	0	0	X	0	0	
Order Cladocera	0	0	X	0	0	X
Class Insecta						
Order Coleoptera						
Family Haliplidae	0	2	X	0	1	X
Order Diptera						
Family Chironomidae	0	0	X	0	1	X
Order Hemiptera						
Family Corixidae	0	0	X	0	0	X
Order Odonata						
Family Lestidae	2	1	X	4	8	X
Family Libellulidae	2	0		0	4	
Class Oligochaeta		0	7	X	0	0
Class Turbellaria		20	23		0	2

Table 2b. Survey of Macroinvertebrate diversity from 1994-2000 at ORW 1 and 2 (Continued after Frazier and Mitsch, 1999).

Classes/Order	1994	1995	1996	1997A	1997B	1998	1999	2000
Gastropoda						X	X	X
Hirudinea						X	X	X
Oligochaeta						X	X	X
Pelecypoda						X	X	X
Amphipoda					X			X
Arhynchobdellia						X	X	X
Basomatophora	X	X	X	X	X			X
Cladocera		X	X					X
Colleoptera	X	X	X	X	X	X	X	X
Collembola			X					
Diptera	X	X	X	X	X	X	X	X
Ephemeroptera	X	X	X		X	X		X
Hemiptera	X	X	X	X	X	X		X
Homoptera			X					
Hydracarina		X						
Maxillopoda		X						
Neuroptera					X			
Odonata X	X	X	X	X	X	X	X	
Opisthopora		X						
Orconectes				X				
Platyhelminthes					X			X
Plesiopora		X			X			
Pulmonata		X			X			X
Trichladida		X						
Trichoptera	X		X	X	X			

Table 3. Comparison of Shannon Indices (H) and evenness (J) from 1997-2000 (Continued after Frazier and Mitsch, 1999) (HD=Hester Dendy plates; FT=Funel traps).

Methods	Speiles (1997)	Custer et al. (1998)	Lowry (1998)	Frazier (1999)	Current study (2000)
HD-W1	H=1.49 J=0.65	H=1.06 J=0.46	H=0.76 J=0.50	H=0.70 J=0.36	H=1.56 J=0.56
HD-W2	H=1.56 J=0.68	H=1.25 J=0.57	H=0.78 J=0.53	H=1.23 J=0.76	H=0.96 J=0.35
FT 1				H=0.78 J=0.56	
FT 2				H=1.02 J=0.74	
FT 3				H=1.23 J=0.79	
FT 4				H=0.46 J=0.29	
BT-W1					H=1.20 J=0.43
BT-W2					H=1.30 J=0.47

wetlands were 69 and 64% in the spring of 1999 but was only 30% in the autumn of 2000. This might be due to seasonal factors, differential flow rate, predation etc., (Zuwerink, 1998) that have been shown to influence the diversity and abundance of organisms in an aquatic habitat.

Certain seasonal trends in the macroinvertebrate numbers have also been shown by Huener and Kadlec, 1992 in a salt marsh in Utah. Corixids were seen to be the most dominant macroinvertebrates in the water column and chironomids among the benthic community (Huener and Kadlec, 1992). The number of macroinvertebrates might be influenced by predatory forces in nature (Safran, R.J. et al, 1997) specially macroinvertebrates like chironomids that are a part of the diet of waterfowls (Euliss and Harris, 1987) and fishes (Batzer et al., 2000). A number of bird species ranging from mallards, wood ducks to flycatchers were spotted in the wetland basins (Zuwerink and Gates, 1999). This could in turn influence the species diversity and richness of these wetland basins.

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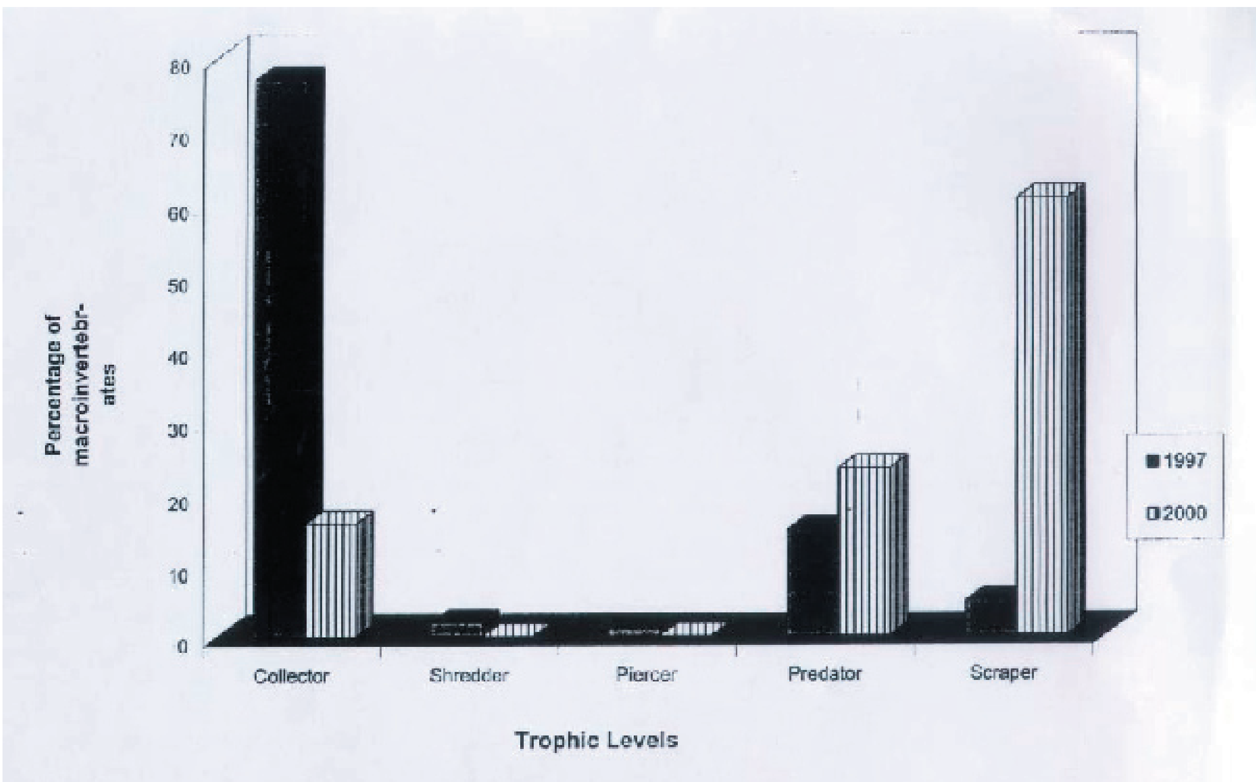

Figure. 2a. Comparitive trophic distribution of macroinvertebrates at the inflow site in W 1 in 1997 and 2000 (Continued after Spieles, 1997).

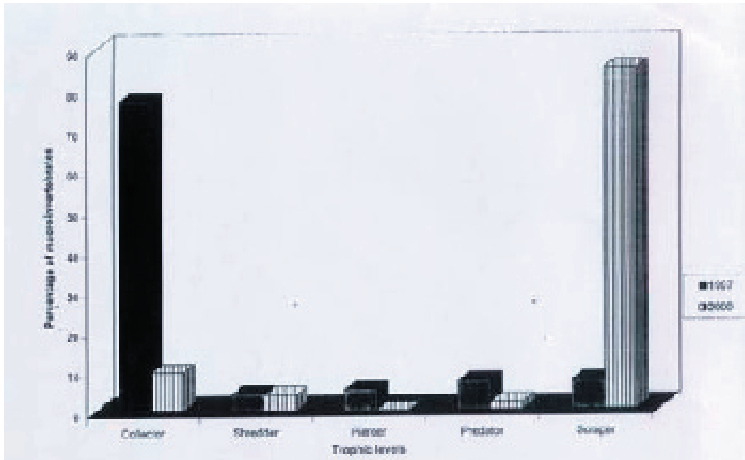

Figure 2b. Comparitive trophic distribution of macroinvertebrates in the middle sampling site in ORW 1 in 1997 and 2000 (Continued after Spieles, 1997).

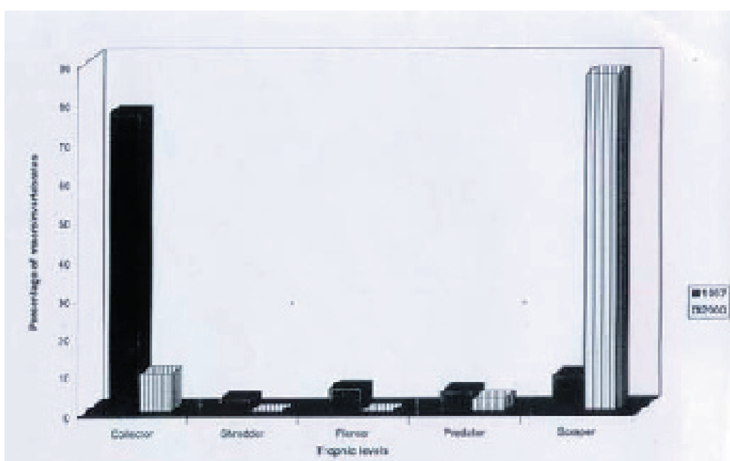

Figure 2c. Comparative distribution of macroinvertebrates in the outflow sampling site in ORW 1 in 1997 and 2000 (Continued after Spieles, 1997).

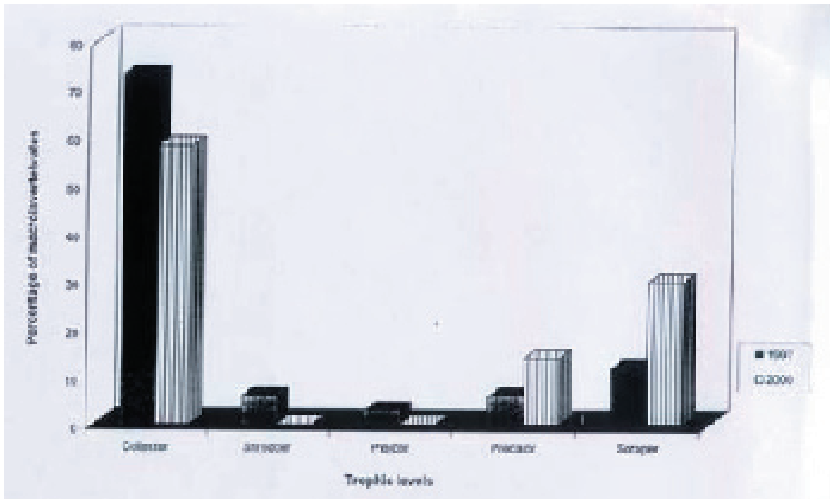

Figure 2d. Comparative distribution of macroinvertebraes at the inflow site in ORW 2 in 1997 and 2000 (Continued after Spieles, 1997).

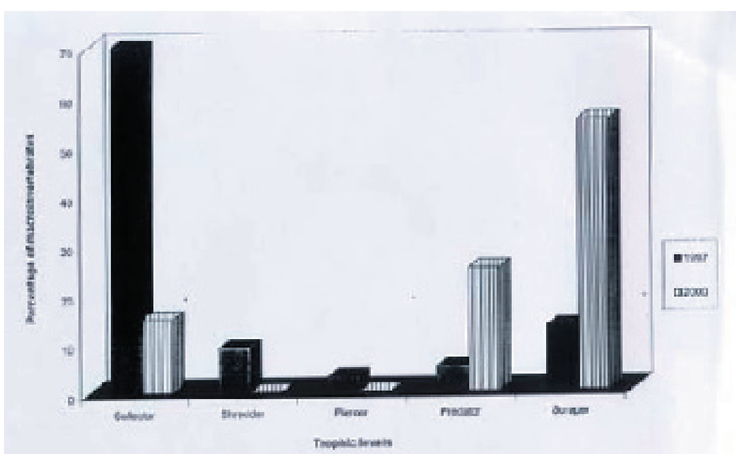

Figure 2e. Comparative trophic distribution of macroinvertebrates at the middle sampling site in ORW 2 in 1997 and 2000 (Continued after Spieles, 1997).

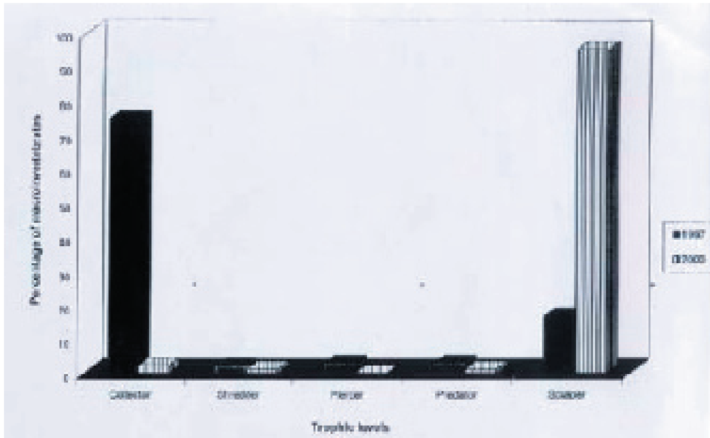

Figure 2f. Comparative distribution of macroinvertebrates at the outflow site in ORW 2 in 1997 and 2000 (Continued after Spieles, 1997).

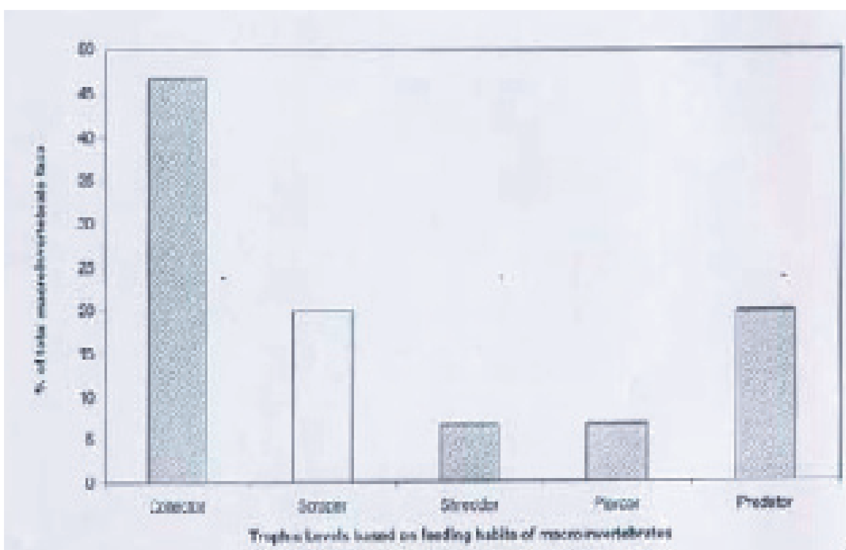

Figure 3. Percentage of total macroinbertebrates as a function of ecological role and feeding habits in Olentangy River experimental wetland basins in October 2000.

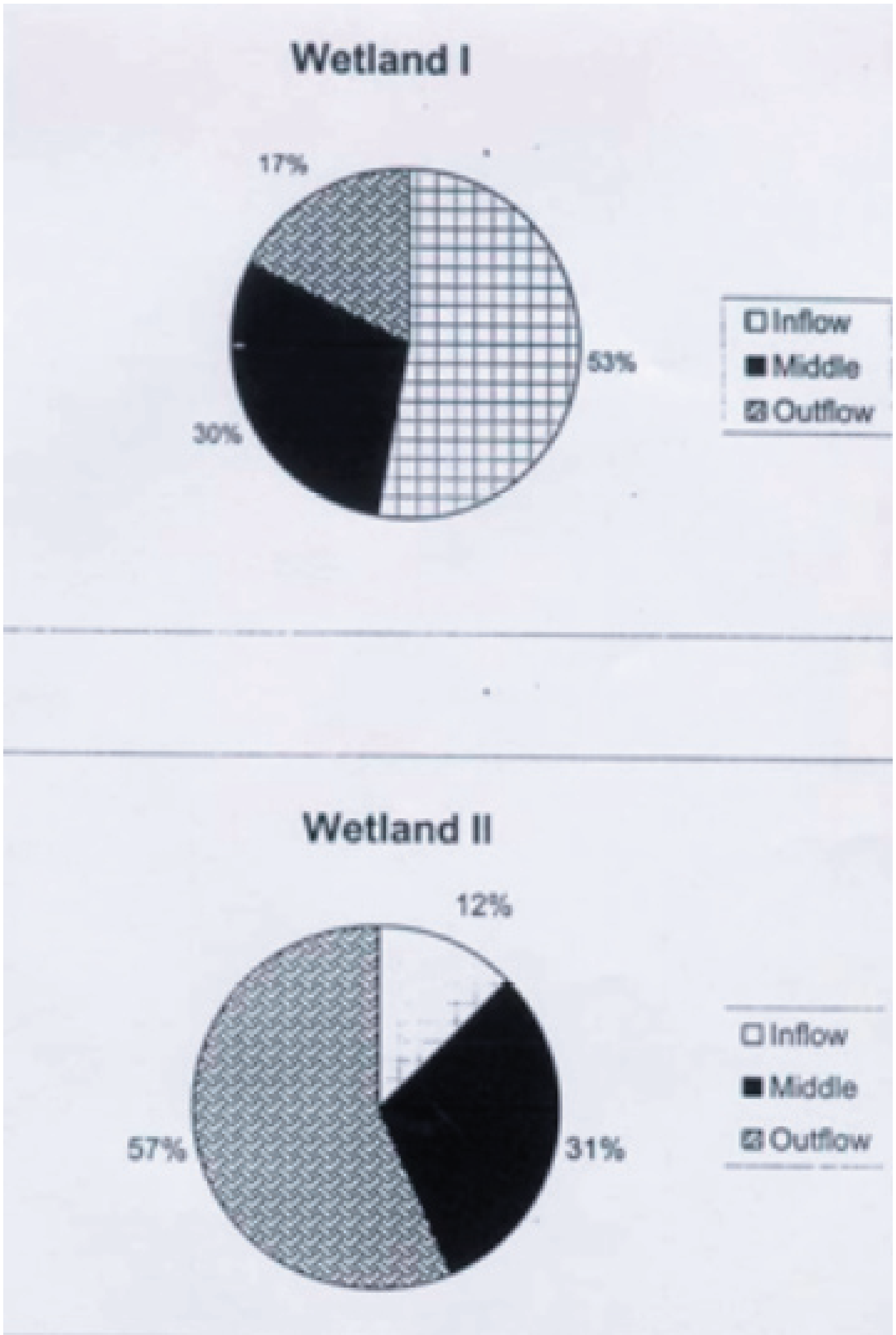

Figure 4. Percentage distribution of macroinvertebrate fauna in Wetlands 1 and 2 in inflow, middle and outflow areas using bottle traps in October 2000.

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